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U. S. NAVAL TECHNICAL MISSION TO JAPAN
CARE OF FLEET POST OFFICE
SAN FRANCISCO, CALIFORNIA

27 December 1945

RESTRICTED

From: Chief, Naval Technical Mission to Japan.
To : Chief of Naval Operations.

Subject: Target Report - Japanese Radio and Radar Direction Finders.

Reference: (a)"Intelligence Targets Japan" (DNI) of 4 Sept. 1945.

1. Subject report, dealing with Target E-05 of Fascicle E-1 of reference (a), is submitted herewith.

2. The investigation of the target and preparation of the target report were accomplished by Lt. Comdr. M.C. Mains, USN(Ret).

C. G. GRIMES
Captain, USN

JAPANESE RADIO AND RADAR DIRECTION FINDERS

"INTELLIGENCE TARGETS JAPAN" (DNI) OF 4 SEPT. 1945

FASCICLE E-1, TARGET E-05

DECEMBER 1945

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

ELECTRONICS TARGETS

JAPANESE RADIO AND RADAR DIRECTION FINDERS

The Japanese were as backward in radio and radar direction finding as in other branches of electronics. Direction finders, as such, were confined generally to ranges below 22 megacycles and were conventional in design, except for the Type 38 experimental land based and the Type 40 experimental shipborne equipments, which were a fair try in the direction of an instantaneous-reading visual-display type of direction finder.

The directional antennae and lobe-switching devices used with radar intercept receivers afforded a means of direction finding at VHF and the lower radar frequencies and are covered in reports on radar countermeasure. See NavTechJap report "Japanese Radar Countermeasures and Visual Signal Display Equipment", Index No. E-07, and the references listed therein.

The Japanese had portable and mobile direction finders, but no information came to light on ultra-portable types suitable for paratroopers.

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REFERENCES

Location of Target:

Second Naval Technical Institute, Meguro Ku, TOKYO, and KANAZAWA, Kanagawa Prefecture.

Naval Bases at YOKOSUKA, KURE, and SASEBO.

Japanese Personnel Interviewed:

Vice Adm. Takeshi NAWA, head of the Radar and Communications Department, Second Naval Technical Institute.

Capt. K. TAKAHARA, head of the Airborne Radar and Intercept Receiver Section of the Second Naval Technical Institute.

Lieut. T. IIDA, senior officer under Capt. TAKAHARA.

Mr. Fred K. UYEMINAMI, engineer in Capt. TAKAHARA's section, who also acted as interpreter.

Reports of Other Agencies:

Electronics Section, Air Technical Intelligence Group (ATIG). Far Eastern Air Forces (Copies to Bureau of Aeronautics and Wright Field):

ATIG #115 - A short Survey of Japanese Radar.

ATIG #276 - Catalog of Radio, Radar, and Special Devices.

ATIG #277 - Miscellaneous Electronics Documents sent to Wright Field.

ATIG #278 - Organization and List of Reports and Equipments, ATIG Electronics Section.

Various reports prepared by Technical Liaison and Investigation Department (TLID) Office of the Chief Signal Officer, Supreme Commander Allied Powers. (Available through G-2, War Department, Washington, D.C.).

LIST OF ENCLOSURES

LIST OF ILLUSTRATIONS

INTRODUCTION

. It was desired particularly to determine whether the Japanese had developed any direction finders in the VHF or microwave ranges, or instantaneous types in any range. With this in mind, all available sources of information were explored, an effort being made to avoid duplications by maintaining close liaison with other agencies investigating the same field.

Since the subject of radar direction finding was adequately covered in reports on radar countermeasures equipment made by this Mission and other organizations, this report is confined to communications direction finders.

Although it appeared that Japanese direction finding techniques were backward, it was thought that the more modern types were of some interest. A short description of each type is given here and additional material on some of the types is available in reports and documents to which reference is made.

THE REPORT

A. SHIPBORNE DIRECTION FINDERS.

All types of Japanese Naval surface vessels were equipped with the obsolete Type 93 Mark 1 direction finder, 30-1000 kc having a rotating loop. The prototype, Type 34, described below, was installed in several ships.

Submarines were equipped with the Type T Mark 5, 100-1000 kc, having a retractable rotating loop. A few were equipped with the prototype Type 29, described below.

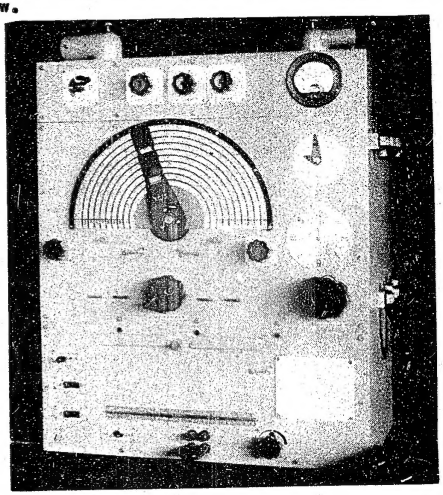


Figure 1
TYPE 29 SUBMARINE RDF RECEIVER

TYPE 29 (SUBMARINE, EXPERIMENTAL)

Frequency Range: 115 kc to 15 mc, in eight bands.

Antenna System: Rotatable single loop, 80cm in diameter, two turns, shielded. RF cable, 230 ohms, led through the tube supporting the loop. Sense Antenna, one meter vertical.

Receiver: Double superheterodyne, uni-control tuning. 6L7G first detector, twelve NF-6 in other stages. Gain, 130 db overall. Intermediate frequencies:

	1st IF.	2nd IF.
115 kc to 500 kc	53 kc	53 kc
500 kc to 4 mc	230 kc	53 kc
4 mc to 15 mc	1010 kc	53 kc

Indication: Aural null.

Accuracy: ±5° at 500 kc for 20 microvolts/meter.
±5° at 4 mc for 10 microvolts/meter.

Manufacturer: Nippon Musen.

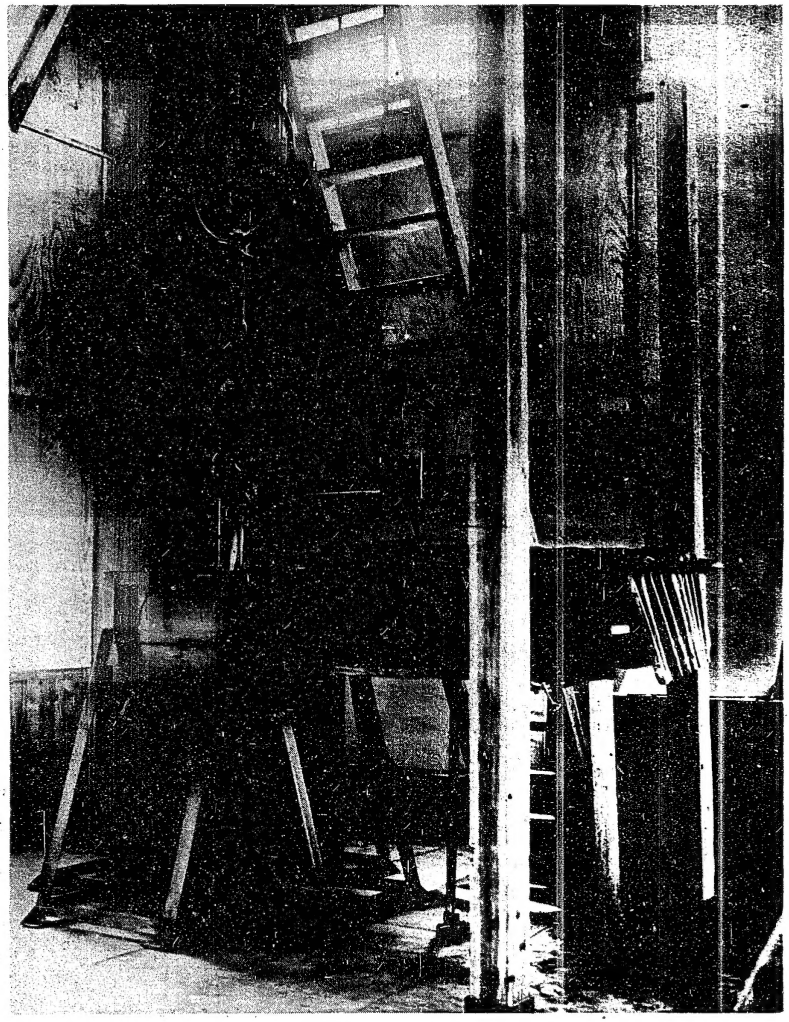


Figure 2
TYPE 29 SUBMARINE RDF LOOP

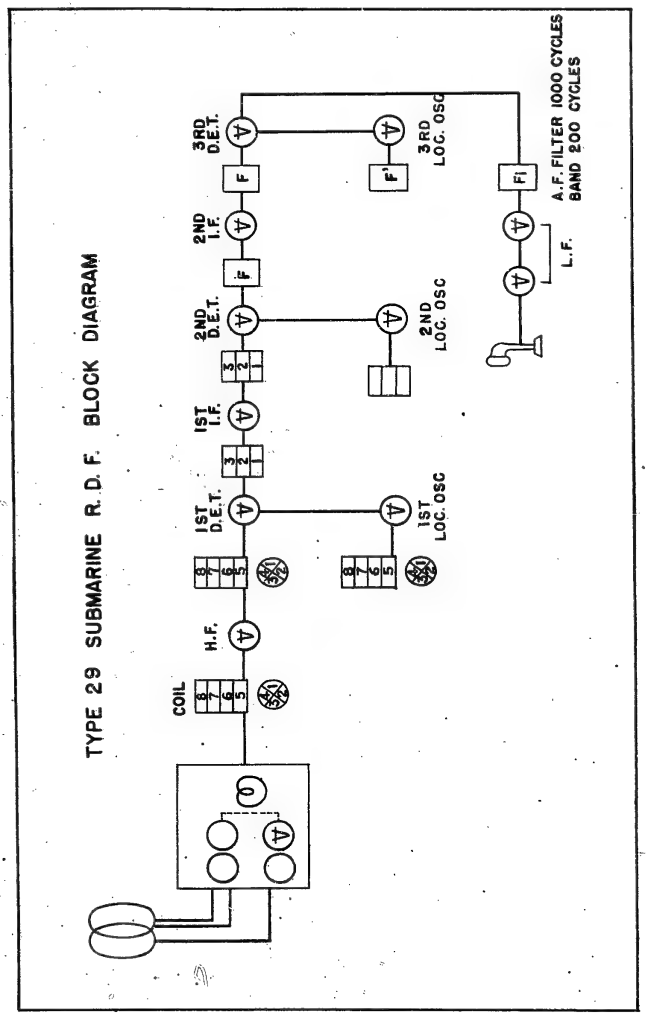

TYPE 29 SUBMARINE R. D. F. BLOCK DIAGRAM
COIL
H.F.
IST D.E.T.
IST I.F.
2ND D.E.T.
2ND I.F.
3RD D.E.T.
IST LOC. OSC
2ND LOC. OSC
3RD LOC. OSC
L.F.
A.F. FILTER 1000 CYCLES
BAND 200 CYCLES

Figure 3

Type 34

Frequency Range:	115 kc to 5 mc.
Antenna System:	Loop aerial, 80cm diameter, six turns, shielded, fixed 90° crossed loop sense antenna, 1.5 meter vertical. RF cable, 230 ohms.
Goniometer:	Plane type. Two used, one for high and one for low frequencies.
Receiver:	Same receiver as used with Type 29 submarine direction finder (see above), except for upper frequency bands.
Accuracy:	± 5° at 500 kc with 30 microvolts/meter. ± 5° at 4 mc with 20 microvolts/meter.
Indication:	Aural null.

TYPE 40 (EXPERIMENTAL)

Frequency Range:	110 kc to 5 mc.
Antenna System:	The same loop antenna and vertical sense antenna as were used for Type 34.
Goniometer:	The same as for Type 34. The goniometer was rotated at 1200 RPM, with the horizontal sweep in synchronism.
Receiver:	The same receiver used with Type 34.
Indicator:	Used a type SSE 75G long-persistence cathode ray tube. The horizontal sweep being in synchronism with the goniometer, a figure-8 pattern was produced on the cathode ray tube, the bisector of the minima indicating the bearing. For sense indication, the vertical antenna was switched in, producing a cardioid types of pattern, the minimum of which was 90° clockwise from the true sense of the bearing.
Remarks:	This was the first recorded attempt by the Japanese to produce an instantaneous-reading type of direction finder for ship use. Type 38 land based equipment was similar in purpose, but used a different antenna system and indicator. One experimental model of the type 40 was obtained by the 5250th Technical Intelligence Co. at TOKOROZAWA and has been shipped to the U.S.

B. AIRBORNE DIRECTION FINDERS.

No outstanding developments in airborne direction finders were found but such information as is available will be found in the reports and documents to which reference is made.

The wiring diagram of the FP Navy airborne direction finder is reproduced in Enclosure (C).

Radar direction-finding is discussed in NavTechJap report "Japanese Radar Countermeasures and Visual Signal Display Equipment", Index No. E-07, and in other reports referred to therein.

C. LAND BASED DIRECTION FINDERS.

Japanese direction finders for land use were generally of the conventional Adcock type. The U-Adcock was used, the H-type having been discarded because of difficulties with antenna balance due to variations in earth conductivity. There was no basic research on antenna systems, though such studies were contemplated. A comprehensive report on errors in collector systems is contained in NavTechJap Documents No. ND21-6000.1 to ND21-6000.14-1. No attempt was made to correct for octantal error. No regenerative receivers were used, and no attempt was made to DF on FM signals. There were no direction finders developed for special applications.

A rule-of-thumb was used in determining the size of the ground mat under the array. The radius of the mat was made at least equal to the radial distance from the center of the antenna to each of the elements, plus the height of the element.

Brief descriptions of the most recently developed models follow and additional information can be found in reports and documents referred to herein.

The Type 97 (portable) direction finder is described in NavTechJap Document No. ND21-6140.1.

TYPE 2 (LAND BASED)

Frequency Range:	500 kc to 4 mc, in four bands.
Antenna System:	(See Figures 4 and 5). Crossed U-Adcock, and vertical sense antenna, height of elements 20 meters, span 30 meters. Each element a cylinder, 30cm in diameter. At the base of each element was a matching box containing antenna coupling coils, tuning condenser, and mercury relay to switch coupling coils. The feeder was run in copper pipe 65mm in diameter, characteristic impedance 350 ohms, run 0.5 meters underground. A net of copper wires, 70 meters in diameter, was buried 0.5 meters underground below the antenna.
Receiver:	Superheterodyne, with 3 stages of RF amplification. Tubes used, 4-6C6, 5-6D6, 1-6L7G, 1-41. Gain, 130 db. Receiver was uni-control, goniometer coils and antenna coupling coils being changed by the same bandswitch. Receiver room was under the center of the antenna array.
Goniometer:	Two pairs, one for low and one for high frequency.
Accuracy:	at 500 kc ± 5° with 7 microvolts/meter. at 4 mc ± 5° with 1 microvolt/meter.

TYPE 3, MODEL 1 (LAND BASED)

Frequency Range:	3 mc to 20 mc, in four bands.
Receiver:	Superheterodyne.
Antenna System:	Crossed double U-Adcock.
Indication:	Aural null.
Accuracy:	± 5° at 20 mc with 2 microvolts/meter. ± 5° at 3 mc with 3 microvolts/meter.
Remarks:	Development completed 1943.

TYPE 2 DIRECTION FINDER ANTENNA

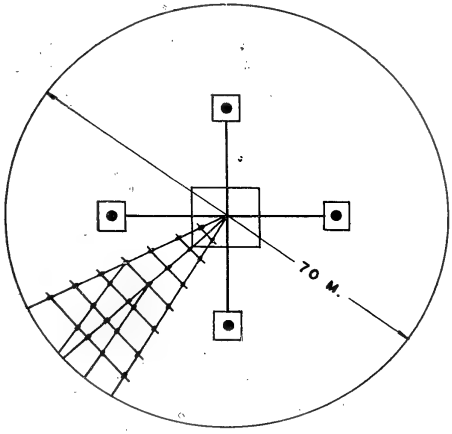


Figure 4
PLAN VIEW

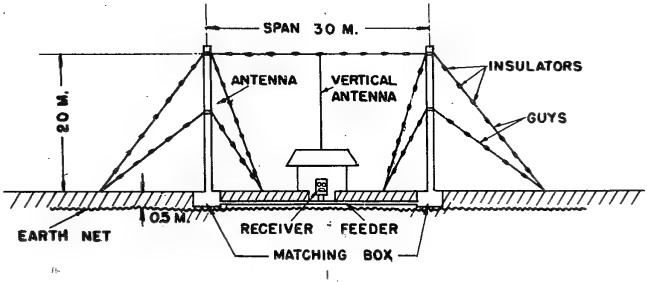


Figure 5
ELEVATION

TYPE 5 DIRECTION FINDER ANTENNA ARRAY

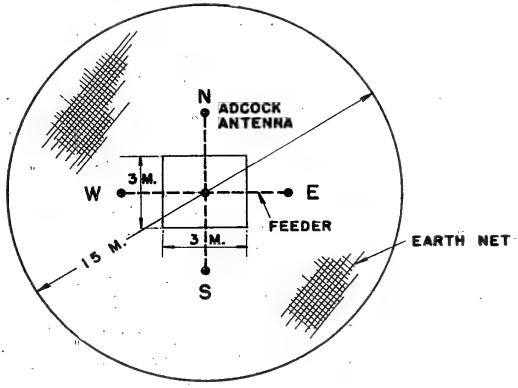


Figure 6
PLAN VIEW

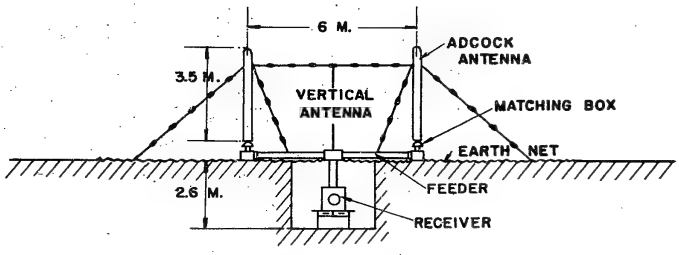


Figure 7
ELEVATION

TYPE 5 (LAND BASED)

Frequency Range: Model A, 4 to 10 mc.
Model B, 2.5 to 7 mc.

Antenna System: (See Figures 6 and 7) Crossed U-Adcock, height 3.5 meters, span 6.0 meters. Watertight matching boxes at base of each element contained coupling coils, 5 turns on both primary and secondary, on a core of Type EI-40 iron oxide having a Q of 10 and of 85. The coupling coefficient was 97% or better. This coupling coil was designed to give high sensitivity and broadband characteristics. The feeder was dual-conductor in a copper pipe of 65mm diameter, characteristic impedance 350 ohms. Under the antenna array was an earth net 15 meters in diameter of 0.5mm copper wire.

Receiver: Short wave receiver Type 3 was used with Model A, and Type 93 with Model B. Both receivers had a gain of 130 db. Receiver room was underground beneath the center of the antenna array.

Accuracy: Model A, $\pm 5^{\circ}$ at 5.0 microvolts/meter.
Model B, $\pm 5^{\circ}$ at 20 microvolts/meter.

Remarks: The apparatus was light in weight and readily installed, intended to be transportable. It was claimed that balance was easily obtained and reliable, and there was no 180° reversal of sense.

TYPE 38 (LAND BASED, EXPERIMENTAL)

Frequency Range: 7 mc to 22 mc, in three bands.

Antenna System: Crossed U-Adcocks and vertical sense antenna, same as Type 2 antenna.

Receiver: (See circuit diagram, Figure 9). Superheterodyne, having 3 channels, one for East-West Adcock, one for North-South Adcock, one for vertical sense antenna. Three stages of resistance-coupled IF amplification, with negative feed-back, IF 30 kc, bandwidth 3 kc (± 1.5 kc). Gain of IF amplifier, 50 db, of converter 10 db. Second local oscillator, 31.5 kc, audio amplifier 3 stages at 1.5 kc, gain 90 db, resistance-coupled. Audio band-pass filter peaked at 1.5 kc, using an inductance with a core of "Sendust F-26", having a μ of 60. The antenna-coupling coil had a core of oxide, Type EI-30 with μ of 50. The grid tuning coil of the converter was wound on a core of "Carbonil Type Tsu-20 T-12", and had a Q of 150 or higher.

Indicator: Type BV-120A cathode ray tube. Type of indication illustrated by sketches in Figure 8.

Remarks: The only existing model of this equipment was the esperimental installation at TOKOROZAWA, said to have been destroyed by the U.S. Army.

This equipment was developed to DF on signals of short duration, to separate bearings from two or more transmitters, and to DF on swinging bearings.

The first breadboard model incorporated a dot-lock feature, which was said to have operated well, but to have been too complicated for actual construction.

TYPE 38 R.D.F. INDICATOR PATTERNS (BV-120A CATHODE-RAY TUBE)

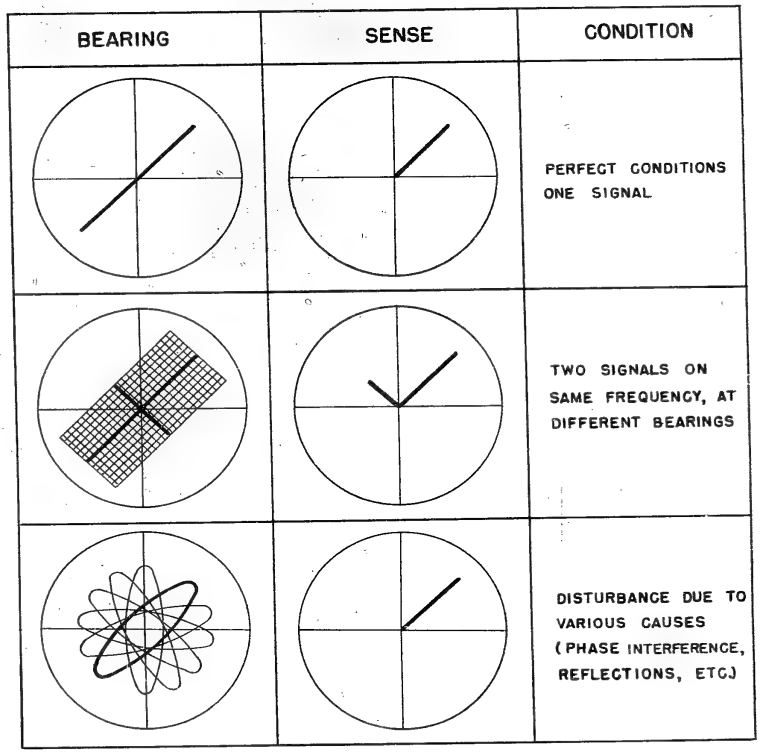


Figure 8

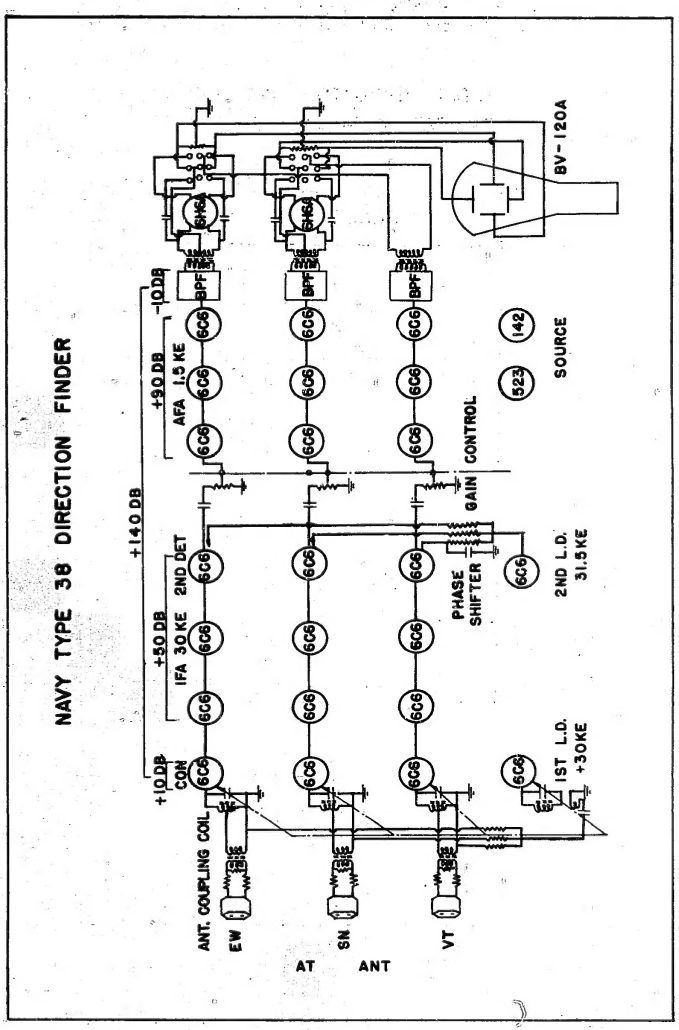

NAVY TYPE 38 DIRECTION FINDER
AT ANT
ANT. COUPLING COIL
EW
SN
VT
CON
IFA 30 KE
2ND DET
AFA 1.5 KE
+10 DB
+50 DB
+90 DB
+140 DB
-10 DB
BPF
6C6
6H6A
BV-120A
PHASE SHIFTER
GAIN CONTROL
SOURCE
142
523
2ND L.O. 31.5 KE
1ST L.O. +30 KE

Figure 9

ENCLOSURE (A)

LIST OF DOCUMENTS FORWARDED THROUGH ATIS TO WDC

NavTechJap No.	ATIS No.	Title
ND21-6000-1	3232	Studies of Electromagnetic Field Disturbances, Part 1: Disturbance of vertical grounded conductor stimulated by vertically polarized waves.
ND21-6000-1-1	3232	Same, Part 2: Electrical field disturbance of a vertical conductor and its effect on direction finding.
ND21-6000.2-1	3232	Same, Part 3: Errors in direction finding due to disturbances of vertical conductor.
NE21-6000.3-1	3232	Same, Part 4: Investigation of electromagnetic disturbances of ship's hull, using model.
ND21-6000.4-1	3232	Same, Part 4: Supplement.
ND21-6000.5-1	3232	Same, Part 5: Methods of correcting for deviation errors.
ND21-6000.6-1	3232	Same, Part 6: Azimuth errors of parrallel type antennas.
ND21-6000.7-1	3232	Same, Part 7: Night errors due to free space disturbance of electromagnetic field.
ND21-6000,8-1	3232	Same, Part 8: The disc body as used with the direction finder.
ND21-6000.9-1	3232	Same, Part 9: Azimuth errors of the 8-element Adcock antenna.
ND21-6000.10-1	3232	Same, Part 10: The 45° Adcock direction finder.
ND21-6000.11-1	3232	Same, Part 11: Investigation of electromagnetic disturbances in vicinity of ship's hull, using model.
ND21-6000.12-1	3232	Same, Part 11: Supplement.
ND21-6000.13-1	3232	Same, Part 12: Electromagnetic disturbances of vertical cylindrical body.
ND21-6000.14-1	3232	Same, Part 13: Errors in direction-finding due to Adcock method.
ND21-6001	3301	Research on experimental Adcock type medium wave land based direction finder.
ND21-6033	3304	Study concerning improving the performance of the present short wave direction finder.
ND21-6124	3305	Loop model RDF installation and errors due to installation.

ENCLOSURE (A), continued

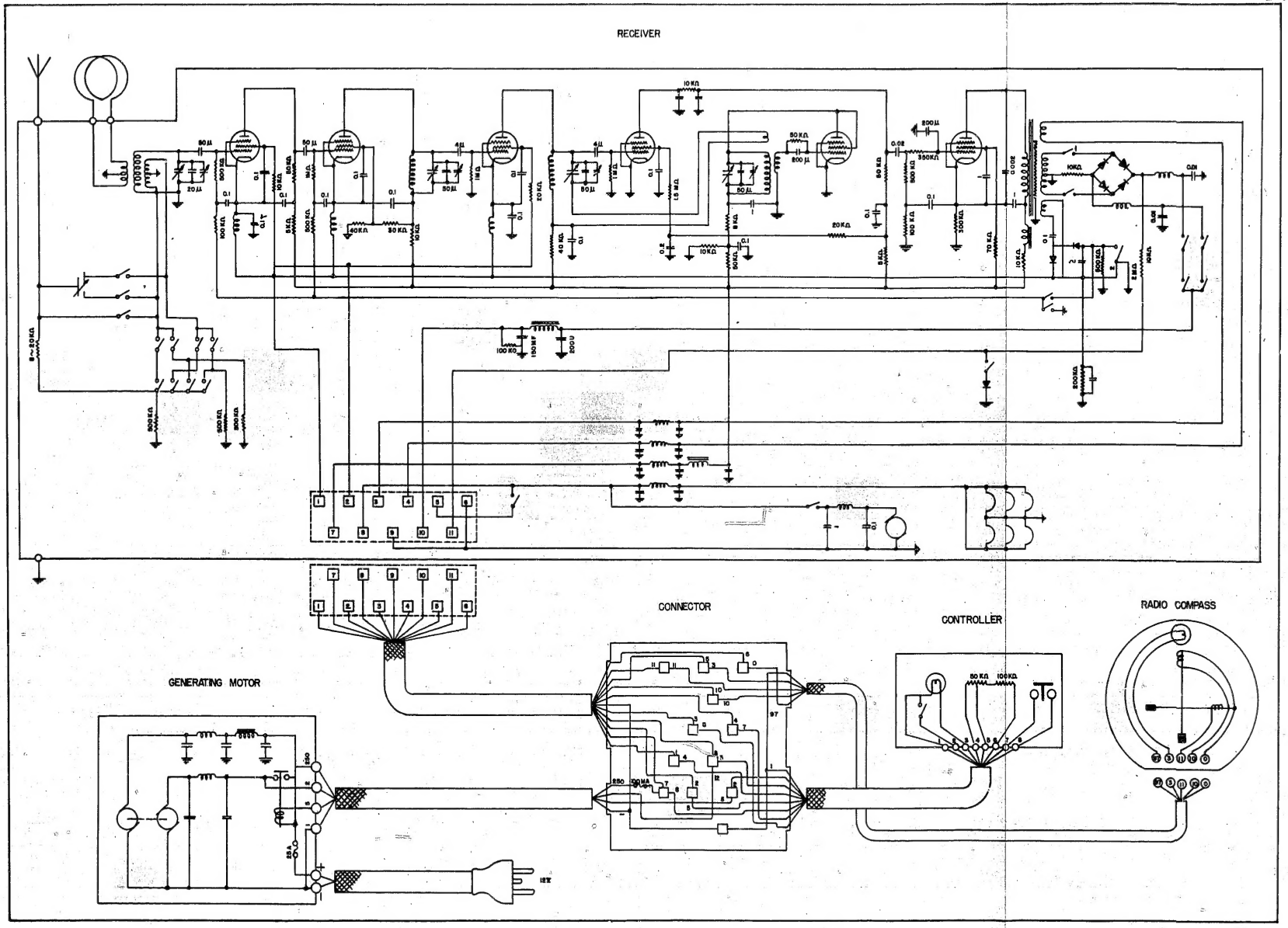
NavTechJap No.	ATIS No.	Title
ND21-6125	3306	Lorenz long wave Model U-Adcock bearing gauge.
ND21-6126	3307	Experimental report, Type O ultra short wave direction finder.
ND21-6129-1	3309	Study of effects of ship's whistle pipe on calibration errors of long wave direction finder, and countermeasures.
ND21-6133-1,2	3313	Short wave RDF, for land use; installation and maintenance.
ND21-6134-1,2	3320	RDF Type 91 Mk2, operating instructions.
ND21-6135	3321	RDF Type 93 Mk1, operating instructions.
ND21-6136	3314	RDF for land use, medium wave. Installation methods and precautions in operation.
ND21-6137-1,2	3322	RDF Type 2 Model 1, installation and maintenance.
ND21-6138-1,2	3323	RDF Type 3 Model 1, installation and maintenance.
ND21-6139	3315	Research relative to errors in Shipboard RDF.
ND21-6140-1,2	3324	RDF Type 97, mobile, operating instructions.
ND21-6141-1,2	3325	Experimental Type 5 Model 1A RDF installation and maintenance.
ND21-6180	3317	Correction of errors of Adcock antenna and goniometer use in wireless course detection gear.

ENCLOSURE (B)

LIST OF EQUIPMENT FORWARDED TO THE NAVAL RESEARCH LABORATORY, ANCOSTIA, D.C.

NavTechJap Equipment No.	Description
JE10-6023(1-8)	Type 93 Mark 1 Radio Direction Finder
JE21-6345(1-4)	Exp 19 Direction Finder 1-Loop Antenna for Small Planes 2-Loop Antenna for Large Planes 3-Direction Finder 4-Loop Rotating Mechanism
JE22-6130	Special Radio Direction Finder (120 to 10000 kc)

ENCLOSURE (C)


RECEIVER
CONNECTOR
CONTROLLER
RADIO COMPASS
GENERATING MOTOR